Optimizing AAC Display Design for Individuals with Developmental or Acquired Disabilities: Contributions of Eye- Tracking Research

Wilkinson, K. M.[1,2], O'Neill, T.[1], Thiessen, A.[3], Light, J.[1], Weiss, A.[1], Liang, J.[1], Fehr, C.[1], & Spencer, J.[1]

[1] Communication Sciences and Disorders, Penn State University

[2] The University of Massachusetts Medical School - Shriver Center

[3] University of Houston

The authors have no financial or nonfinancial interest in the technology reported in this presentation, and our reporting on its use is not an endorsement.

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Outline

- Rationale for Studying Visual/Cognitive Processing in AAC
- Introduction to eyetracking
- Visual attention to Traditional Grid Displays by individuals with neurodevelopmental disabilities (Wilkinson et al)
- Visual attention to Visual Scene Displays by individuals with neurodevelopmental disabilities (O'Neill et al)
- Visual attention to AAC displays by individuals with traumatic brain injury or aphasia (Thiessen)

Imagine I were taking a trip, and I asked you to help me by finding some information about renting cars in the UK.

And imagine I sent you to a site like this – which is a website for someone who leases cars.

If you found this website confusing and hard to use, you would likely abandon it, right? ….
….. And you would find some other means to access information about UK car rentals.

I would argue that individuals who use AAC likely have similar responses.

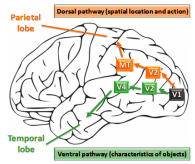
When we offer them an AAC display that is confusing and hard for them to use, they may opt not to use it and instead find some other, less conventional means to communicate.

Basic theoretical framework for the research to be presented today:

We know that understanding the principles by which people process sounds is important in order to design the most optimal oral/aural language interventions both for children who are learning to speak as well as for individuals with acquired language disorders

Knowing how individuals hear and process sounds helps optimize oral language interventions

It seems equally important to understand principles of visual processing when putting together a visually-based aided AAC intervention



http://www.intechopen.com/books/visual-cortex-current-status-and-perspectives/adaptation-and-neuronal-network-in-visual-cortex

Knowing how individuals attend to and process visual information is necessary to help to optimize visual aided AAC interventions

A quick browse of the web indicates that variations in the physical realization of AAC displays are likely the norm……

If the perceptual features of displays don't really matter, then any one of those displays can be used with any client.

But that seems unlikely.

In this presentation, we will demonstrate using eye tracking technology how different system design features influence visual attention by individuals with a variety of disabilities, to various types of AAC displays.

The goal is to illustrate how eye tracking can provide a window into important processes underlying AAC, in populations that are otherwise quite difficult to test using traditional means, due to language or cognitive impairments.

And we will demonstrate that, in fact, design does likely matter

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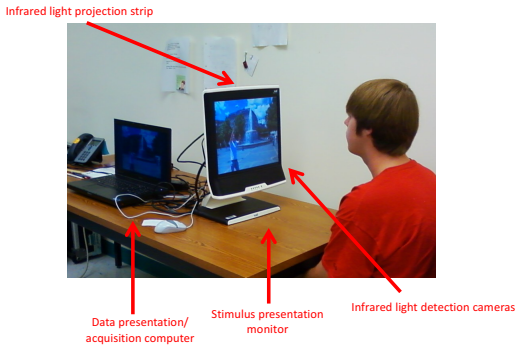
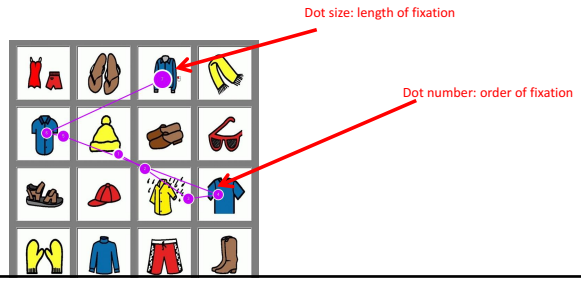
All of the studies to be reported today use the Tobii T60 eye tracker.



Every 16 ms a sample of the eye gaze position is obtained, providing a running log of gaze patterns (order, length, etc).

Below is what is called a "gaze plot", which represents the fixation path for one participant, on one trial.



Another handy way of visualizing fixation patterns across more than one participant: the "heatmap"

This represents the fixation intensities aggregated across 5 different participants who viewed this image.

Darker red = greater intensity of fixation (can be higher number or longer duration)

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Attention to grid-based displays by individuals with neurodevelopmental disabilities

Krista Wilkinson, Jiali Liang, Amelia Weiss, & Jessica Spencer

Financial Disclosure statement: Funded by

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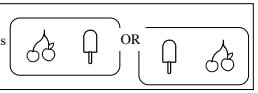
- NICHD R01 HD083381;
- Hintz Communicative Competence Award (Penn State University)

Wilkinson & Jagaroo (2004) reached into the field of visual cognitive neuroscience and identified two potentially powerful perceptual dimensions relevant to AAC. These have served as our proof-of-concept dimensions: (i.e., does design matter?)

Symbol Structure: Color
To what extent does symbol color enhance or inhibit processing?

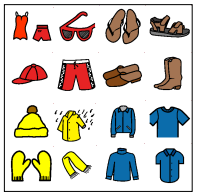
Spatial Layout: Symbol Location
Does the location in which we place symbols affect how easily they are processed?



General Approach for all the studies I will describe: Visual Search

Our research-based eye-tracking technology, which I will describe, also allows me to determine where participants actually look, while they are finding the target

Find the….



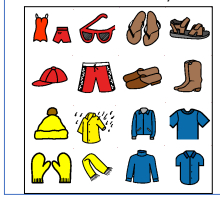
We can measure if our participants locate the target correctly (accuracy), as well as how quickly they find it (latency). Both measures matter for effective aided communication.

I typically use a mouse click response.

1. Target appears by itself on the screen:

2. Upon mouse click, target disappears and is replaced by an array in which…

Choices are clustered by color



OR

Choices are distributed by color

Initial data: Individuals with Down syndrome or ASD (Wilkinson & McIlvane, 2014)

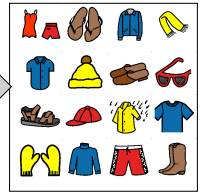
This first study looked only at speed and accuracy of locating a target, via mouse click.

For BOTH groups we found that clustered is superior to distributed:

Choices are clustered by color

Is superior to

Choices are distributed by color

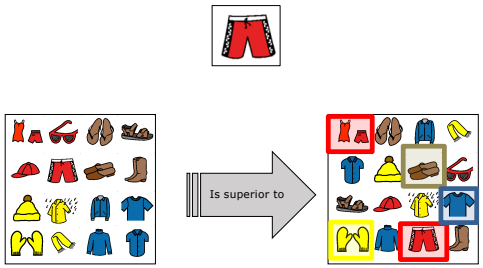


Incorporation of eyetracking:

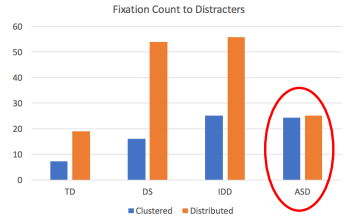
The response accuracy and speed tells us THAT there is an advantage for clustered display.

However, it does not tell us WHY clustering is superior.

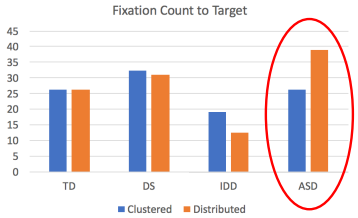
Recording the pattern of visual fixation during search, however, brings us closer to the WHY…



Is it that people are looking differently at the target?
Are people fixating more on the like-colored foils?
Or are people fixating more on the unrelated distracters?



These patterns were true for 100% of subjects in each group. We are currently expanding the subject numbers to see if these initial results hold up



Conclusions

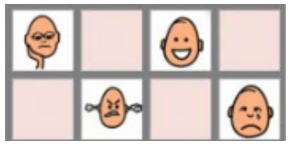
- For ALL participants, making simple changes to the organization of a traditional grid-based AAC display affects the efficiency with which individuals locate information on those displays.
- Individuals with ID are reported to have particular difficulty inhibiting attention to non-target stimuli (Lanfranchi et al., 2009, 2010; Munir et al., 2000), a conclusion reinforced by these findings. From the standpoint of AAC, it is critical to reduce unnecessary sources of distraction.
- These changes are made to the display itself and require no instruction of the individual. Their effects on performance will be immediate, thus readily implemented.

What you've done so far focusses on symbols where the symbol internal color CAN be changed, and one CAN arrange them on the basis of that color.

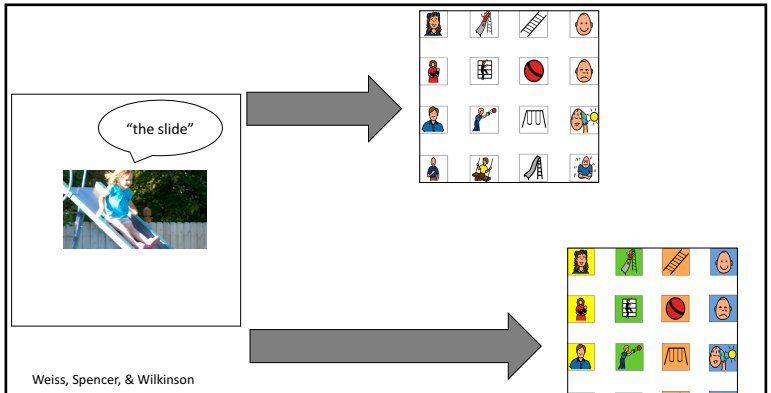
But what about symbols where we can't change internal color, or arrange them on that basis?

We would never recommend violating naturally-occurring coloration of different objects – for instance:

And internal color coding won't work for symbols for people, actions, emotions, objects, and descriptors



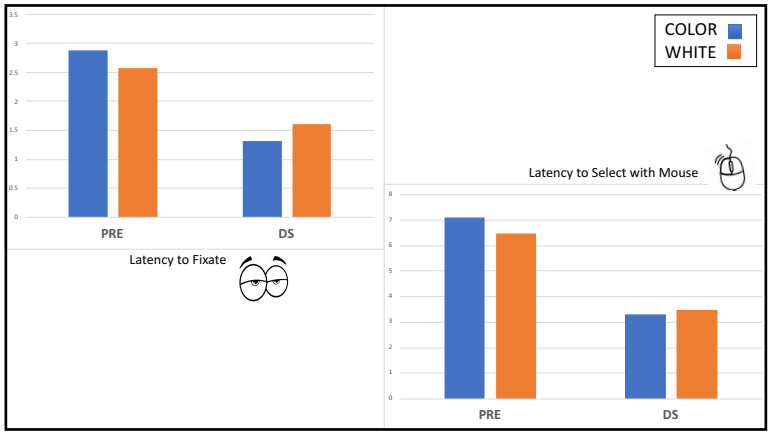
Maybe color coding the background of symbols would be an effective cue…



Weiss, Spencer, & Wilkinson

Participants:

- 12 individuals with Down syndrome (DS)
- 12 preschool children matched on vocabulary age estimate (PRE)

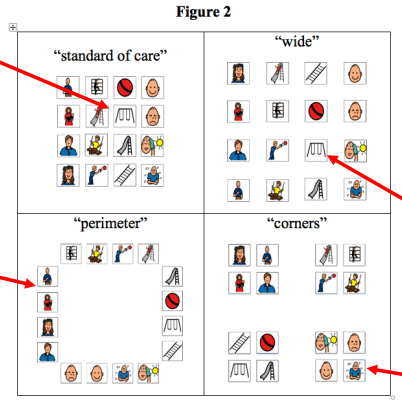


Conclusions

- Background color cues did not assist with either facilitating fixation or response time to words of different word-class categories, in individuals with Down syndrome or in vocabulary-matched preschool children.
- There may be times when symbol background color cues helps – larger grids, etc – but just be aware….

If background color cuing is not an effective cue for finding a symbol, then what can we use?

Maybe spatial cues?

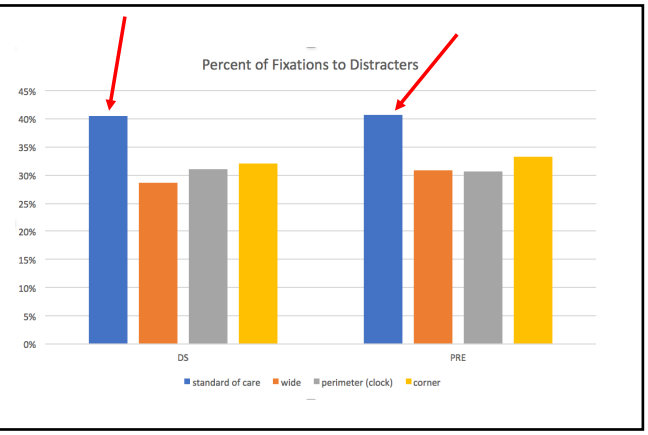


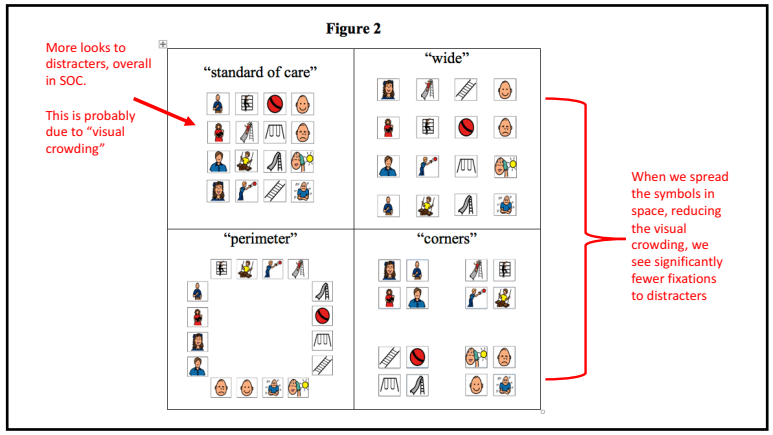
Vision science would suggest that in this display, "visual crowding" may be an issue – that is, the target has many close neighbors, which is visually crowded.

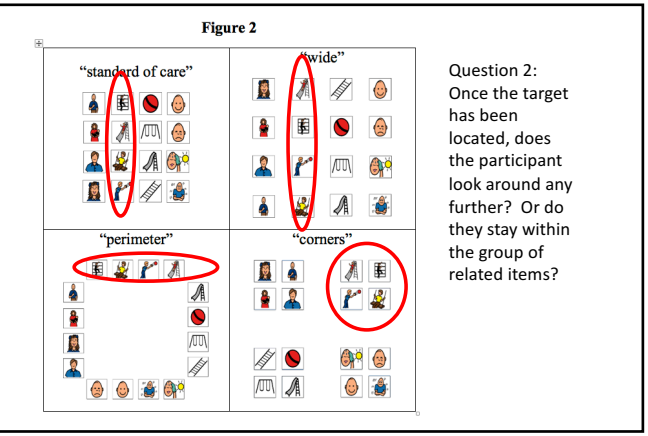
These two displays are not symmetrical grids, but instead use space to highlight the word-class groupings, either by arranging them in groups around the perimeter, or in the corners

The "Wide" condition still uses the symmetrical grid, but reduces visual crowding

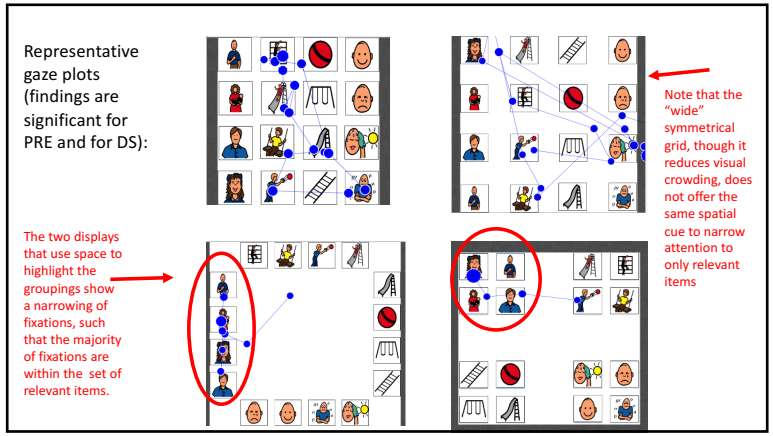
Question 1: Do different arrangements lead to different numbers of fixations on distracters?







Question 2: Once the target has been located, does the participant look around any further? Or do they stay within the group of related items?



Conclusions

- In contrast to background color cues, spatial arrangement clearly and without doubt facilitates attention to targets, and away from non-relevant items.
- Judicious use of space, and where possible symbol-internal color cues, seems to be the key to facilitating search on AAC grids.
- Overall conclusion: Design matters, and it matters for everyone….
  - Next step (currently underway) – how do these different designs influence attention and behavior during actual communication interactions?

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Investigation of eye gaze on AAC visual scene displays (VSDs) with a navigation menu

Tara O'Neill, Krista Wilkinson, Janice Light, & Caroline Fehr

Financial Disclosure: Funded by:

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- NIDILRR AAC-RERC grant #90RE5017

Visual scene displays (VSDs)

- A VSD is one type of AAC display in which representations of concepts are embedded in an integrated scene (e.g., photograph)
- Benefits of VSDs:
  - Capture the **social interactions** in which children learn language
  - Provide **contextual** and **event-based** support for language learning

Wilkinson, Light & Drager, 2012

Previous investigations of eye gaze in photographs

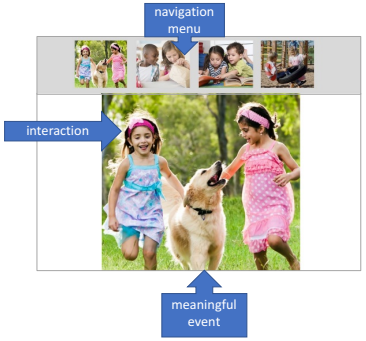
- Humans in photographs attract visual attention, even when they are small, offset, and next to potentially distracting items in the background (Wilkinson & Light, 2014)

TD DS IDD ASD

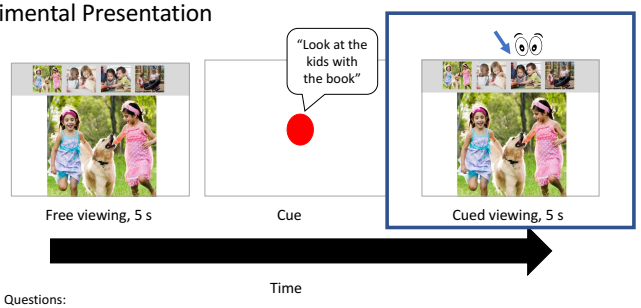
This investigation furthers previous research by examining eye gaze fixation patterns on stimuli that resemble actual VSDs

However, AAC visual scene systems are often more complex than a single picture.

Particularly, children must be able to visually attend to and navigate between various displays within a dynamic display system.



Experimental Presentation



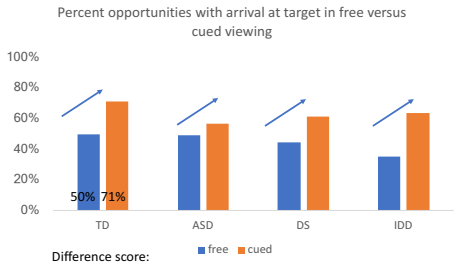
Questions:

- In how many opportunities do participants arrive at the cued target? (free versus cued)
- For those participants who arrive at the target, how long do they spend fixating on the target? (free versus cued)

Participants

group	number	CA (average)	PPVT age equivalent (average)
ASD	16	14;7	4;2
DS	15	17;8	4;6
IDD	15	15;11	5;11
TD children	20	4;1	5;1

Accuracy: In how many opportunities do participants fixate on the cued target? (Group results)

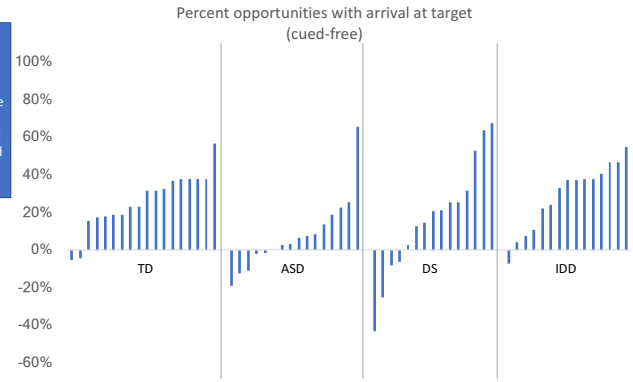


Difference score:
71%-50%= 21%

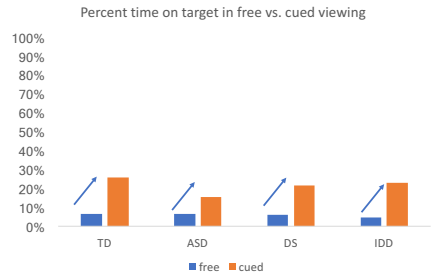
Participants show an increase in the likelihood of fixating on the target after presentation of the cue.

We can calculate a difference score. For example…

What happens when we look at the difference scores for individual participants in each group?

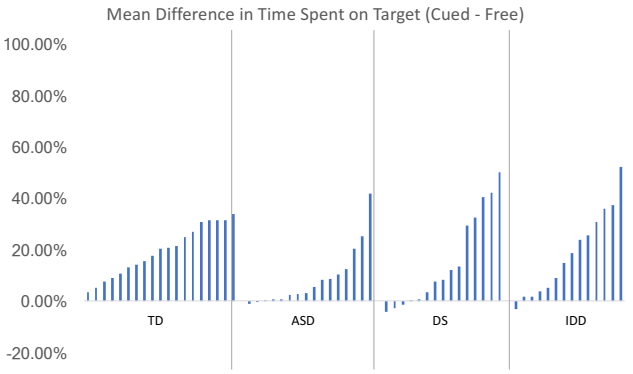


Scrutiny: For those participants who arrive at the target, how long do they spend fixating on the target? (Group results)



Participants spend a greater proportion of their fixation time on the target in cued viewing compared to free viewing.

Again, we can calculate difference scores and look at the individual data.

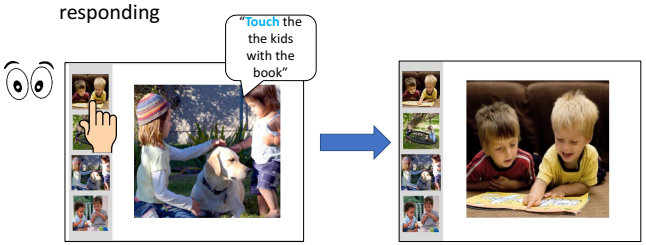


Implications

- Provision of a cue produced reliable variations in how participants fixated on a target in the two viewing phases
- Eye-tracking may be a valuable methodology to gain information about individuals with significant intellectual and developmental disabilities who are challenging to assess using traditional behavioral assessments
- Exploration of individual factors that contribute to variability in performance within groups is needed
- Could we map a threshold for measuring comprehension?

Next steps

- Navigating an AAC device requires not only visual attention, but also a motor response (i.e., selecting a target from the menu)
- In our next study we will investigate both visual and motor responding



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Adults with Acquired Neurological conditions

Amber Theissen

Funded by:
- NIDILRR AAC-RERC grant #H133E080011

Why Eye-Tracking for Adults with Acquired Conditions?

- People with traumatic brain injury (TBI) or aphasia often rely on aided AAC
- Must understand how they extract meaning and process information presented in AAC displays
- Difficult to assess through traditional means

Aphasia and Eye-Tracking

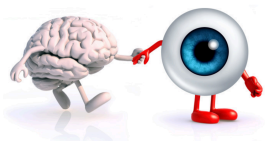
- Reading deficits → image-based supports
- Expressive language deficits hinder ability to explain attention, processing, and image design preferences
- Eye-tracking
  - requires minimal expressive language skills
  - objective measurement

TBI and Eye-Tracking

- Cognitive, motor, language challenges → Use aided AAC supports
- Decreased metacognitive skills = limited ability to explain processing of images and displays
- Eye-tracking
  - Requires minimal metacognitive skills
  - Objective measurement

Vision Deficits in TBI

- Accommodation issues
- Blurred vision
- Double vision (diplopia)
- Eye strain
- Field cuts
- Decreased peripheral vision
- Visual-vestibular disorders



Negatively affect aided AAC use!!

(Greenwald, Kapoor, & Singh, 2012; Politzer & Lenahan, 2010; Ripley & Politzer, 2010)
Image from http://www.minnesotavisiontherapy.com/what-is-vision-therapy

TBI and Eye-Tracking Research

Message Representation

Participants
9 Adults with TBI
9 Controls

Procedure
Grids presented for 10 seconds

Participants instructed to locate and visually fixate on target

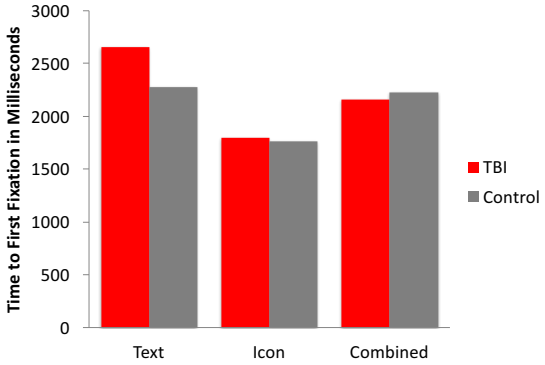
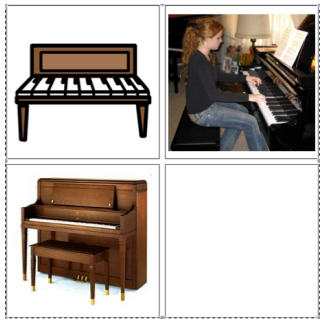


Image Preference and Message Type



2 Conditions

1. Naming

"Which of these would you choose if you wanted to say piano?"

2. Action

"Which of these would you choose if you wanted to tell me about playing music?"

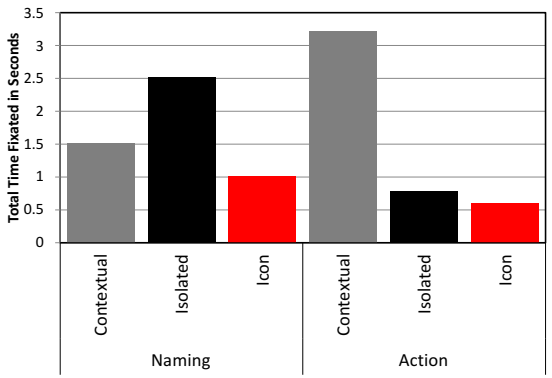
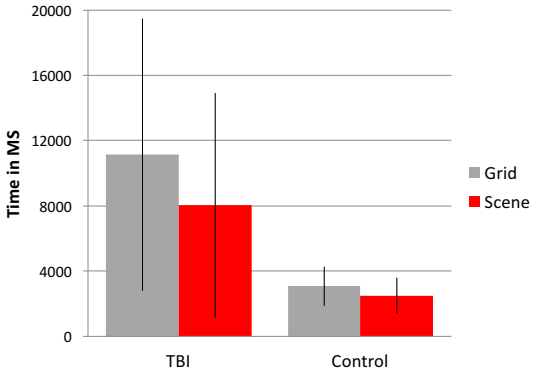
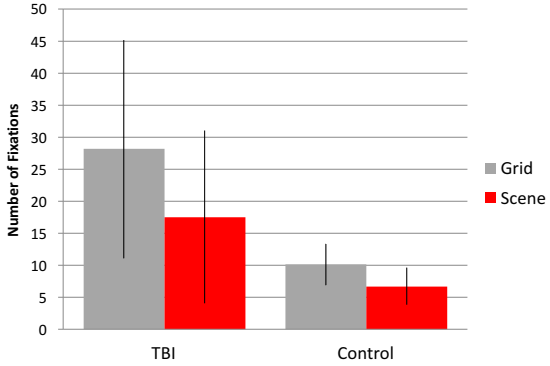


Image Identification

Participants
- 13 Adults with TBI
- 13 Control participants

Procedure
- View images on eye-tracker monitor
- Press button when ready to identify
- Verbalize image theme





Aphasia Eye-Tracking research

Participants
- 10 adults with aphasia

Areas of Interest
- Person
- Object
- Background

Free viewing for 7 seconds

**Response to engagement cues

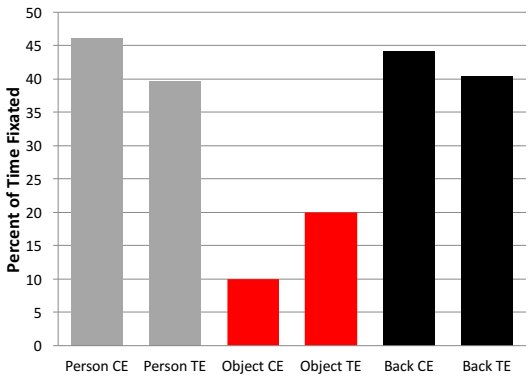
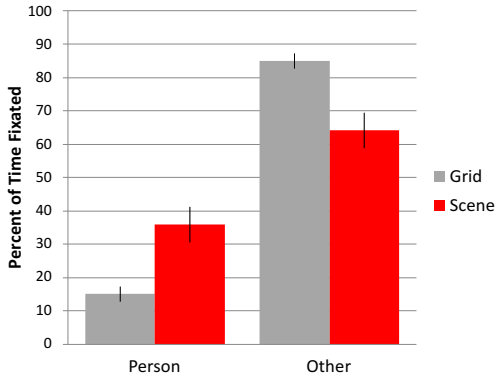


Image Identification

Participants
- 5 Adults with Aphasia

Procedure
- View images on eye-tracker monitor
- Press button when ready to identify
- Verbalize image theme



Conclusion

- Eye-tracking technology is becoming an increasingly prominent tool in AAC research
- Affords a unique view on cognitive processing that would otherwise be difficult to gather from individuals with severe communication deficits
- Much work to be done in the future

Questions?